Bendix
Aerospace Systems Division

Central Station Specification (Array E)

NO.	REV. NO.
AL 210100	

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DATE 13 August 1971

PERFORMANCE, DESIGN

AND

PRODUCT CONFIGURATION REQUIREMENT

FOR

CENTRAL STATION SUBSYSTEM

FOR

APOLLO LUNAR SURFACE EXPERIMENTS PACKAGE

Approved: _____
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1.0 SCOPE

This specification establishes the requirements for performance, design, test and qualification of the Central Station subsystem for Apollo Lunar Surface Experiments Package (ALSEP), Array E.

The Central Station shall be the communications link between the deployed experiments of the ALSEP and the Earth-based Manned Space Flight Network (MSFN). It shall also convert power from the Radioisotope Thermoelectric Generator (RTG) for distribution to the experiments.

The Central Station shall be compatible with the primary and alternative groups of experiments of Array E, as follows:

Prime Array	Lunar Mass Spectrometer Experiment (LMS)
	Lunar Ejecta and Meteorites Experiment (LEAM)
	Heat Flow Experiment (HFE)
	Lunar Surface Gravimeter Experiment (LSG)
	Lunar Seismic Profiling Experiment (LSPE)
Alternative Array:	In the alternative Array E the LSG experiment is deleted and the following substituted:
	Passive Seismic Experiment (PSE)

2.0 APPLICABLE DOCUMENTS

The following documents, of the exact issue shown, form a part of this specification to the extent specified herein. In the event of conflict between documents referenced here and other detail content of Sections 3, 4 and 5 the detail requirements of Sections 3, 4 and 5 shall be considered superseding.

PROJECT DOCUMENTS

NASA Office of Manned Space Flight

NPC 500-1 16 November 1964	Apollo Configuration Management Manual
MSC Supplement No. 1	(To NPC 500-1) Revision B, 26 April 1965
NHB 5300.4 (1B) April 1969	Quality Program Provisions for Aeronautical and Space System Contractors

SPECIFICATIONS

Contractor

SS 100000	ALSEP System Specification
BSR 2777	Bendix Aerospace Systems Division Quality Assurance Plan for ALSEP
IC 314106B	Interface Control Specification Passive Seismic Experiment Subsystem for ALSEP
IC 314109C	Interface Control Specification Heat Flow Experiment Subsystem for ALSEP
IC 314132	Interface Control Specification Lunar Mass Spectrometer Experiment Subsystem for ALSEP
IC 314115	Interface Control Specification for MSFN/ALSEP
IC 314133	Interface Control Specification Lunar Surface Gravimeter Experiment Subsystem for ALSEP

IC 314119	Interface Control Specification Electrical Power Subsystem for ALSEP
IC 314131	Interface Control Specification Lunar Seismic Profiling Experiment Subsystem for ALSEP
IC 314130	Interface Control Specification Lunar Ejecta and Meteorites Subsystem for ALSEP
AL 240000	Structure/Thermal Subsystem Specification
ARD 116 (AL 310100)	Antenna for Central Station for ALSEP
AL 310210	Power Distribution Unit for Central Station for ALSEP
AL 310500	Diplexer and Switch for Central Station for ALSEP
AL 310810	Command Decoder for Central Station for ALSEP
AL 310910	Data Processor for Central Station for ALSEP
AL 770000	ALSEP EMI Specification
ARD 503	Transmitter for Central Station for ALSEP
AL 410600B	Redundant Command Receiver for Central Station of ALSEP
AL 510100	Power Conditioning Unit Specification

STANDARDS

Military

MIL-STD-130C	Identification Marking of U.S. Military Property
MIL-STD-721B	Definitions of Effectiveness Terms for Reliability, Maintainability, Human Factors and Safety
MIL-STD-889	Metals, Definition of Dissimilar

NASA

DS-1	System Accessibility for Maintenance
DS-7	Systems Checkout Provisions
PS-37	Electrical Connections - Disconnection for Trouble Shooting Bench Testing

OTHER PUBLICATIONS

Bendix Documents

ATM 242, Rev. E	Approved Materials List for ALSEP
ATM 241, Rev. E	Acceptable Parts List for ALSEP
SE 33	Measurements Requirements Document - Array E
ATM 930	Command List, Array E

(Copies of specifications, standards, drawings, bulletins and publications required by suppliers in connection with specific procurement functions should be obtained from the procuring activity or as directed by the contracting officer.)

3.0 REQUIREMENTS

3.1 Performance

The Central Station Subsystem shall receive, decode, and distribute commands from the MSFN to the deployed units of the ALSEP, including some commands for the control of internal Central Station Subsystem functions. It shall accept and process experiment digital data, analog status and engineering information from the experiments, and analog status and engineering information from the Central Station thermal, data, and power subsystems. This information shall be processed into a digital telemetry format and transmitted back to earth as an S-band signal. The Central Station Subsystem shall interface and operate with the MSFN as specified in IC 314115.

The Central Station Subsystem shall also accept power from the Radio Isotope Thermoelectric Generator at a constant level, and shall process it to suitable voltage and power levels for use by the ALSEP system. Figure 1 is an outline functional diagram of the basic Central Station Subsystem.

The C/S Subsystem comprises the following units interconnected as shown in Figures 2 through 5.

a. Antenna, Specification AL 310100

b. Diplexer and Switch, Specification AL 310500

c. Command Receiver, Specification AL 410600B

d. Command Decoder, Specification AL 310810

e. Data Processor, Specification AL 310910

f. Transmitter, Specification ARD 503.

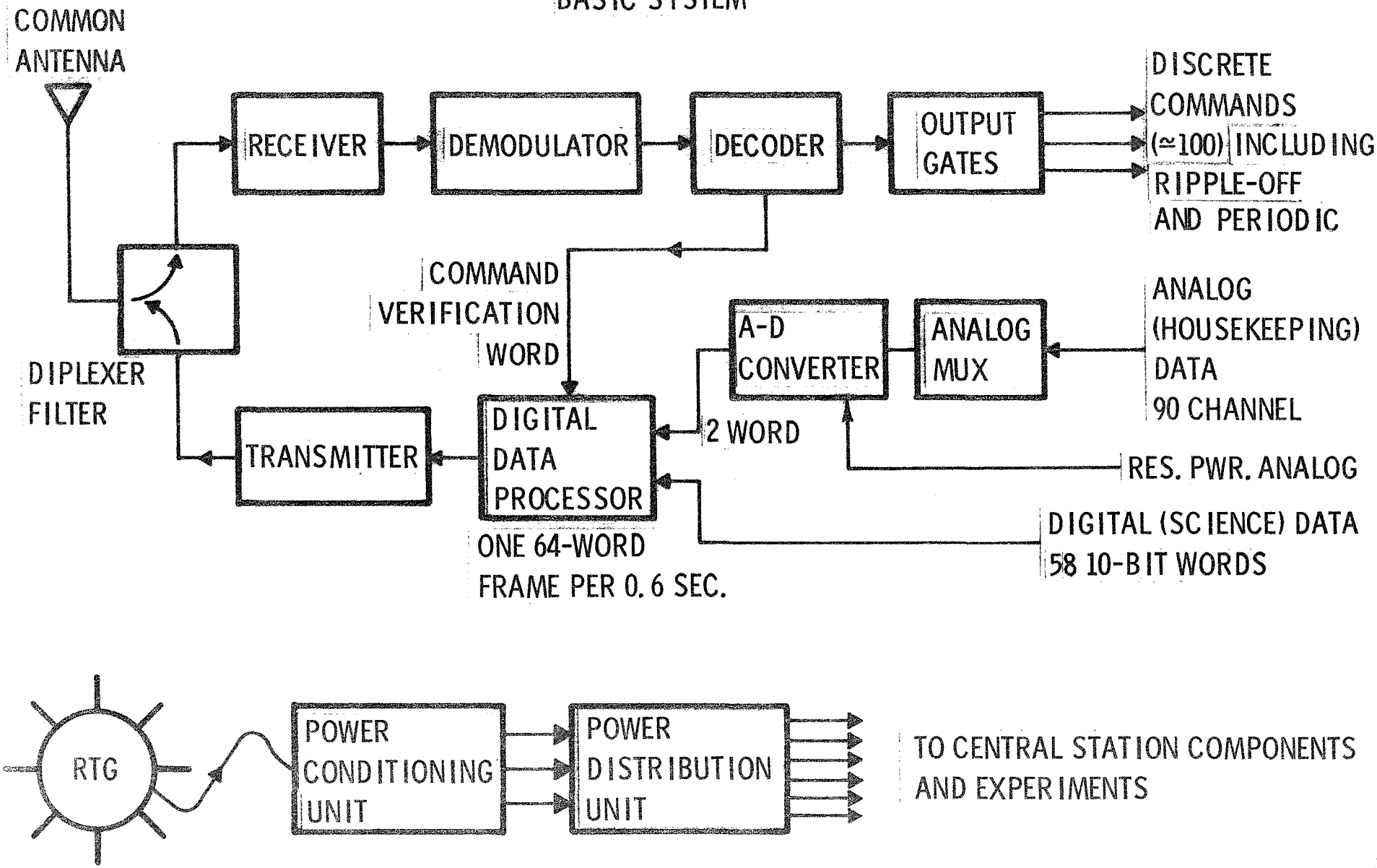
g. Power Distribution Unit, Specification AL 310210

h. Power Conditioning Unit, Specification AL 510100.

The uplink command function utilizes a. through d. and g. while the data transmission back to Earth utilizes a., b., e., f., g., and h. The power function utilizes g. and h.

FIGURE 1

BASIC SYSTEM



3.1.1 Operational Characteristics

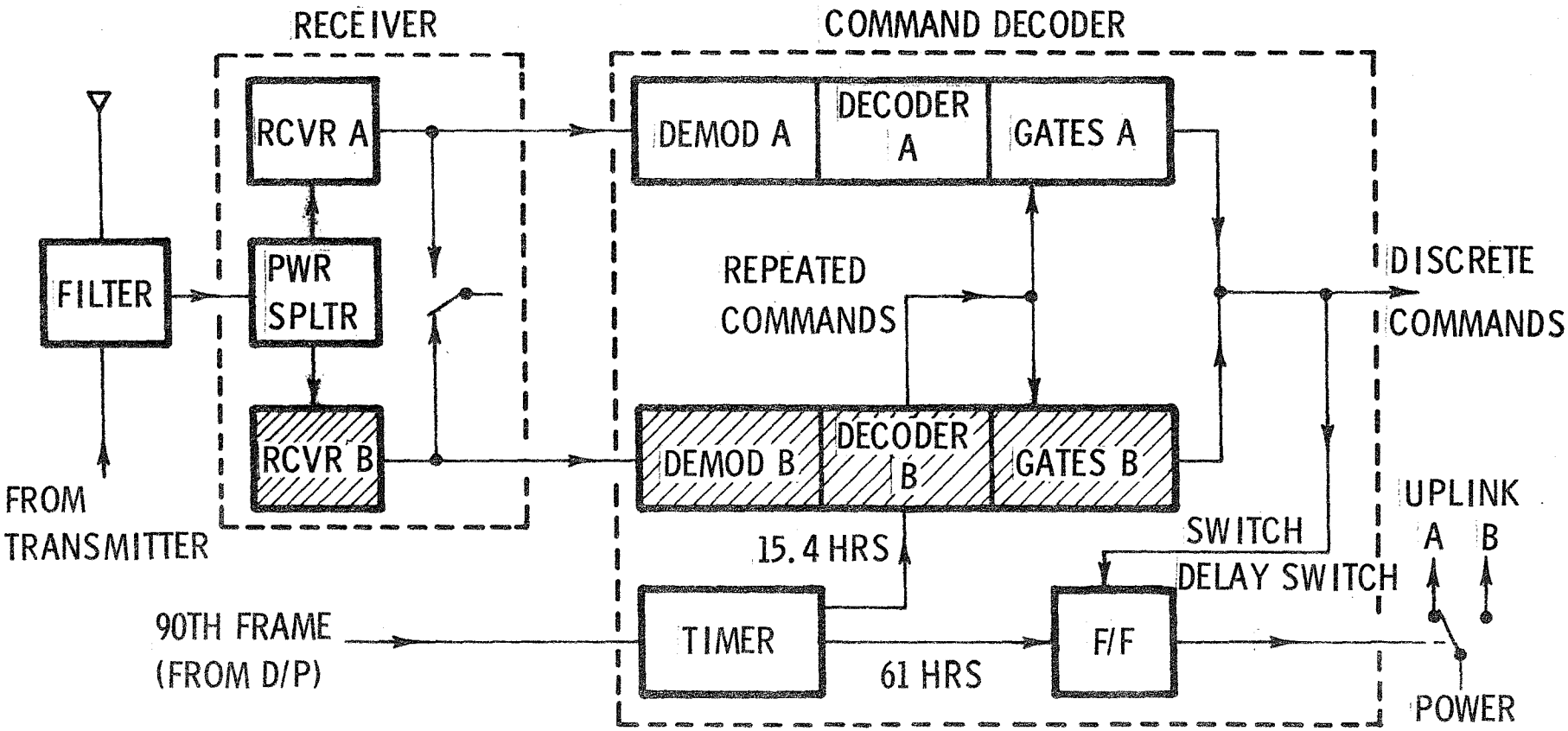
The Central Station Subsystem shall be capable of simultaneous reception of commands and transmission of data via a common antenna. The commands shall be received on a frequency common to all ALSEP (see paragraph 3.1.1.1), but the transmission of data shall be on a frequency allocated only to Array E (see paragraph 3.1.1.2). In order to obtain the level of reliability required for two-year operation all components of the Central Station Subsystem shall be redundant, except for the Antenna, Diplexer and Diplexer Switch. Figures 2, 3 and 4, 5 and 6, show respectively the redundant uplink, downlink, and power arrangements for Array E. Except for the case of the redundant transmitter the redundant unit not in use shall have its power turned off and it shall not be possible to turn both redundant units off at the same time. In the case of the transmitters (see Figure 3) they shall be commanded independently and may be on/on, on/off or off/off, although the normal arrangement shall be one on and the other off.

In the uplink (see Figure 2) each chain, consisting of receiver, demodulator, decoder and command output gates, shall be operated as one unit, with no cross-strapping to the redundant chain, except at the initial RF input and final command output points. A counter circuit utilizing the downlink timing pulses shall ensure that if the uplink initially selected fails then the redundant uplink will be brought into operation automatically, either within 7 hours of initial lunar deployment or thereafter with a maximum delay of 61 hours (122 hours in Slow Bit Rate mode). It shall not be possible to inhibit the automatic uplink switching function permanently except by transmitting a specific command (Octal 174) at least once every 61 hours. A changeover from one uplink chain to the other shall be commandable by MSFN at any time (provided that the uplink in use correctly decodes command Octal 122) and shall override a previous uplink switch delay command. A power overload by the uplink in use shall cause an immediate switch to the other uplink.

In the downlink (see Figure 3) the redundant Analog Data Processors (ADP, consisting of multiplexer and analog-digital converter), Digital Data Processors and Transmitters shall be selectable in any combination by ground command. In the cases of the DDP and the ADP, power overloads shall produce an immediate switchover to the redundant unit. In the case of the transmitter an overload shall simply switch the faulty unit off, requiring an uplinked command to switch the redundant transmitter on.

FIGURE 2

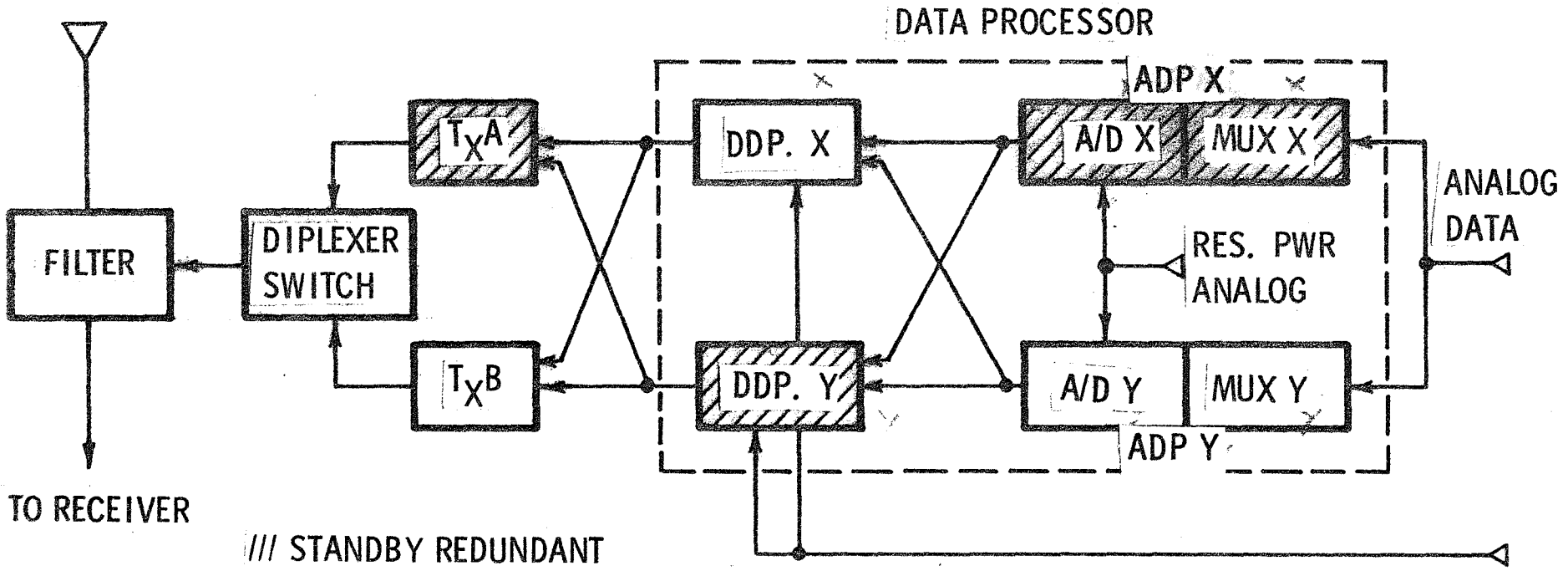
ARRAY E UPLINK



////// STANDBY REDUNDANT

- ONLY ONE SIDE OF UPLINK POWERED AT ANY TIME.
- NO MISSION TERMINATION DEVICE.
- REPEATED COMMANDS DO NOT INCLUDE TURN-ON FUNCTIONS.

FIGURE 3
ARRAY E DOWNLINK



- DDP AND ADP SELECTED ON 'EITHER-OR' BASIS.
- TRANSMITTERS ARE CONTROLLED INDEPENDENTLY.
- ADP COMBINED WITH DDP IN ONE UNIT.

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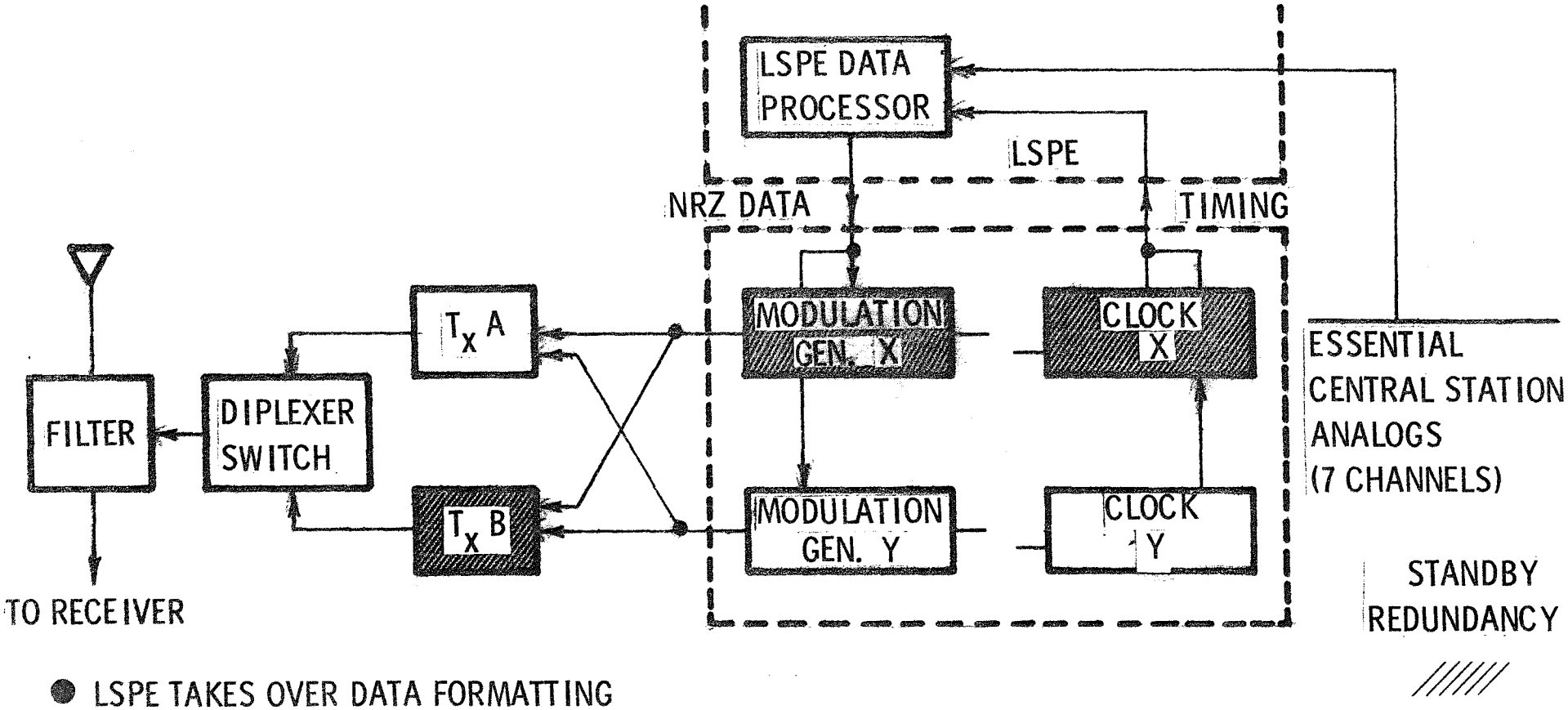
FIGURE 4
ARRAY E DOWNLINK

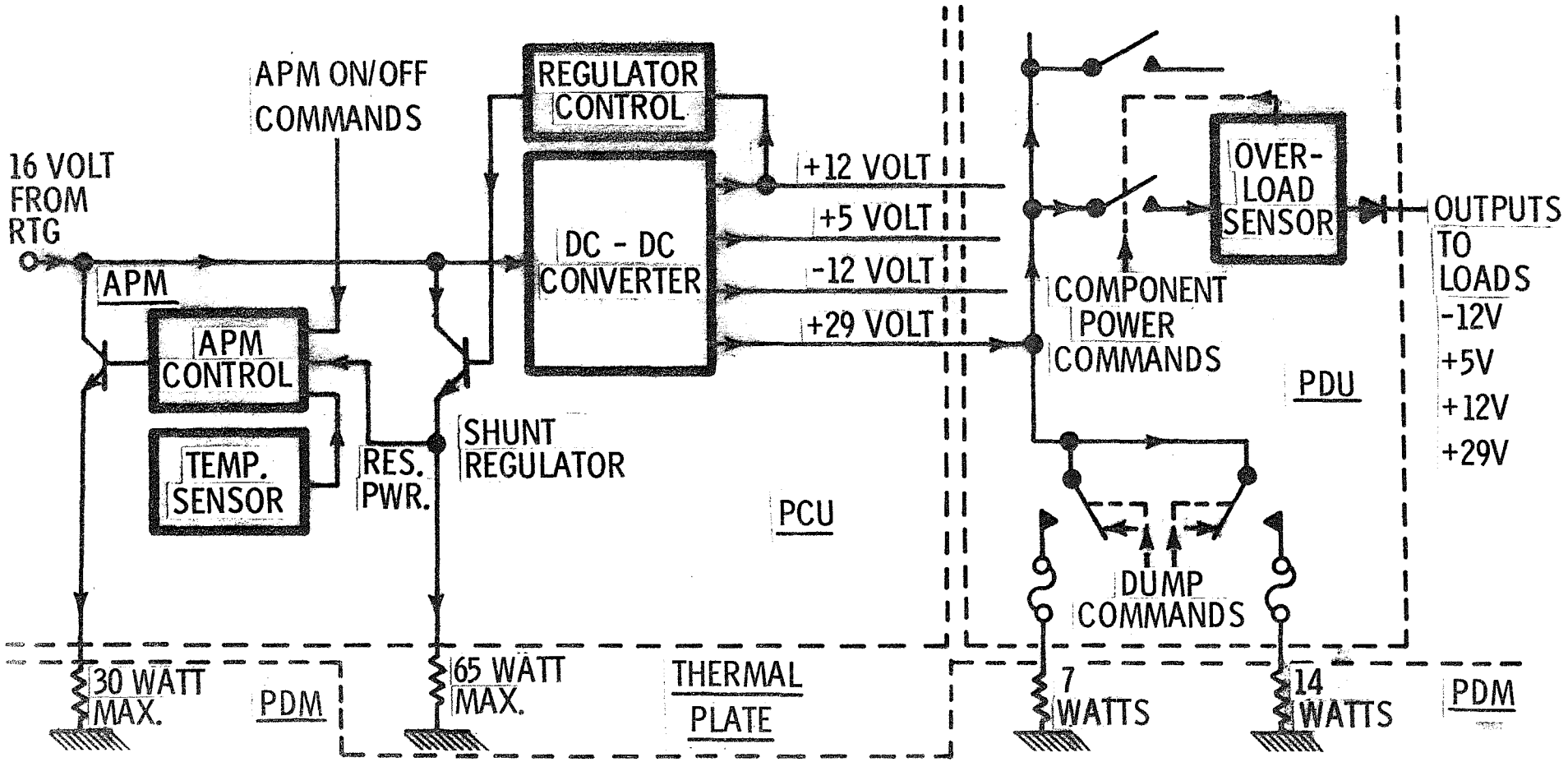
(LSPE MODE)



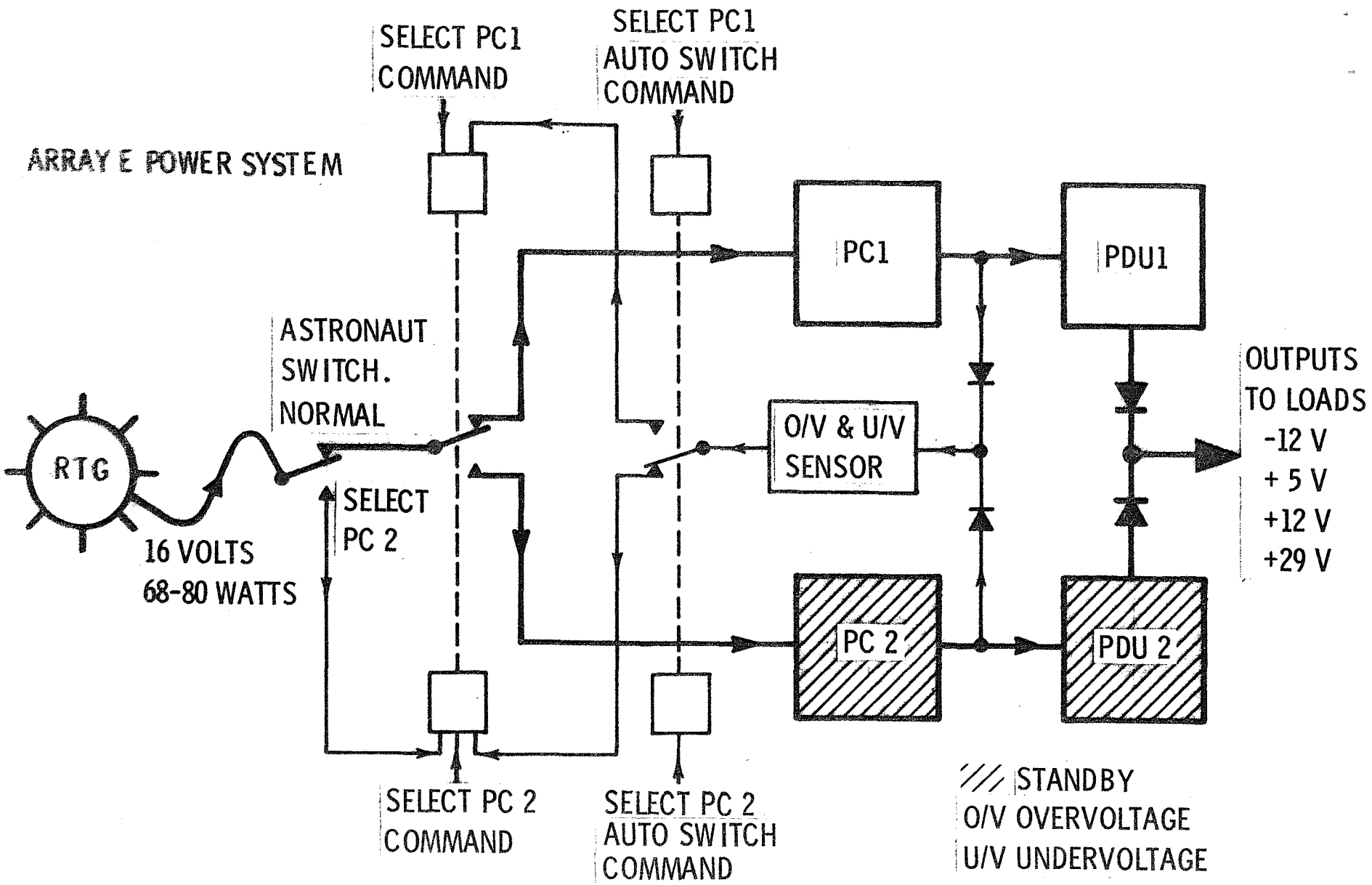
- LSPE TAKES OVER DATA FORMATTING
- ONLY LSPE AND ESSENTIAL ANALOG DATA TRANSMITTED
- UPLINK NOT AFFECTED
- REDUNDANCY OF RELEVANT DOWNLINK COMPONENTS RETAINED

FIGURE 5 ARRAY E POWER SYSTEM

(NOTE: PCU AND PDU ARE REDUNDANT. ONLY ONE SIDE SHOWN.)



- RESERVE POWER DISTRIBUTED BY AUTOMATIC POWER MANAGEMENT SYSTEM FOR THERMAL CONTROL. CONDITIONS FOR APM DUMPING ARE (1) "APM ON" AND (2) RESERVE POWER GREATER THAN 2 TO 4 WATTS AND (3) TEMPERATURE GREATER THAN 60°F TO 80°F.
- THERMAL CONTROL BACKUP BY FIXED COMMANDABLE DUMPS.
- CORRESPONSING RELAYS IN REDUNDANT PDU ALWAYS TRACK EACH OTHER.



- COMPLETELY REDUNDANT PCU/PDU WITH DIODE ISOLATED OUTPUTS.
- ASTRONAUT SELECTS PC#2 IF PC#1 FAILS TO START.
- AUTO-SWITCH TO REDUNDANT PC POSSIBLE IN EITHER DIRECTION.
- TO PREVENT 'BELLING' THE O/V-U/V SENSOR MUST BE COMMANDED TO APPROPRIATE SIDE.

FIGURE 6

When the Lunar Surface Profiling (LSP) experiment is in operation it requires the whole of the downlink format, at an increased data rate, in order to obtain an adequate information rate. A means shall therefore be provided, as in Figure 4, to allow the LSPE to take over all downlink formatting, using only the basic clock and split-phase modulation facilities of the Central Station Subsystem Data Processor. During this mode of operation there will be no scientific data downlinked from the other experiments and only seven analog channels will be available for non-LSP quantities.

In the power system (see Figures 5 and 6) there shall be no cross strapping except at the common input from the RTG, and at the diode-isolated common outputs from the Power Distribution Units. Although only one PC and PDU pair shall be in use at any time for converting and distributing power to the ALSEP system it is a requirement that the relays in the redundant Power Distribution Unit shall always track the settings of the relays in the PDU in use so that no unnecessary changes in the power distribution situation shall occur in the event of an automatic or commanded PCU/PDU changeover.

The power system shall be preset for flight to the PC #1 state and a means shall be provided to enable the astronaut to select PC #2 manually in the event that PC #1 fails to start following initial lunar deployment. Once satisfactory operation is obtained with either redundant power chain a means shall be available whereby the other power chain will be automatically selected in the event of subsequent out-of-regulation operation. The power system shall seek to maintain itself in regulation by automatically applying the following measures, in the order shown:

(a) Removal of gross individual overloads by direct circuit-breaker or fuse operation. (Experiments switched to "Standby", power dumps blow fuse, transmitter switched 'OFF', redundant systems changed over)

(b) Sequential removal (ripple-off) of loads, on the basis of scientific priority, to ensure an adequate margin of reserve power for regulation purposes (Experiments switched to Standby, power dumps to 'OFF')

(c) Changeover to the redundant PCU/PCU combination in the event that a complete ripple-off of all loads fails to achieve regulation.

The automatic PCU/PDU changeover circuit shall preclude any possibility of "belling", that is continually switching from one to the other, and it shall be acceptable for the automatic switchover circuit to be specifically enabled in the appropriate direction by ground command in order to achieve this end.

A changeover from one PCU/PDU chain to the other shall be commandable at any time.

In addition to the basic power conversion and distribution functions the Central Station Subsystem power circuits shall automatically distribute reserve power (that is power which is surplus to current requirements) in the appropriate manner between internal heater and external dumps, so as to seek to maintain the Central Station within prescribed temperature limits. In the event that the permissible Central Station temperature limits are exceeded the Automatic Power Management (APM) circuit shall not have the capability of removing other loads; the situation shall be assessed and rectified by ground command.

3.1.1.1 Reception

The Central Station shall receive transmissions from earth MSFN sites on a frequency of 2119 MHz ±0.001 percent. The received signal power at the command receiver shall be in the range of -92 dbm to -60 dbm. The received signal modulation provides command data as bi-phase modulation of a 2 KHz sine wave subcarrier. A 1 KHz sine wave sync signal is linearly added to the 2 KHz subcarrier. The resultant signal phase-modulates the 2119 MHz carrier. The amplitudes of the 1 and 2 KHz signals are equal. The peak deviation of the carrier is ±3.00 radians +10% -1%. A bit "one" begins when the positive transition of the 1 KHz sync signal (sine wave) and the 2 KHz information signal (sine wave) cross each other in phase. A bit "zero" begins when the positive transition of the sync signal crosses the information signal 180° out of phase. The bit period is 1 millisecond.

The Central Station subsystem shall provide a capability for decoding a minimum of 100 discrete logic commands. These commands shall be used to perform power switching, thermal control, mode changing and experiment control. The command rate shall not exceed 1 per second during the normal mode of downlink operation (data rate of 1060 bps) and 1 per 2 seconds during the slow mode of downlink operation (data rate of 530 bps).

3. 1. 1. 2 Transmission

In the Data Processor Formatting Mode the Central Station Subsystem shall accept digital NRZ-(c) data signals from the experiment at a 1060 ± 0. 01% bps rate synchronized to the Data Processor by means of control and timing signals supplied to the experiments by the Data Processor. Upon command from the Earth MSFN, the data rate shall be capable of being changed to 530 ± 0. 01% bps (Slow mode). Demand lines shall be provided to each telemetry user (except LSPE) to control digital data read-out to the C/S Data Processor. The logic levels of the digital data and demand signals shall be as follows:

a. Logical "1", + 2. 4 to + 5. 5 volts.

b. Logical "0", 0. 0 to +0. 4 volts.

In addition to the digital data the subsystem shall accept and multiplex up to 90 status and engineering (housekeeping) analog signals in the range 0 to +5 volts, for 8-bit analog-to-digital conversion, and insertion into a single word of the downlink frame. An additional single word per frame shall contain the 8-bit digital conversion of the reserve power analog.

All data transmitted im the Data Processor Formatting mode shall be in a frame format containing 64 ten-bit words. Experiment output data shall be NRZ-c; conversion to split phase (Manchester) code shall occur in the Central Station Subsystem Data Processor.

Provision shall be made in the telemetry frame for a command verification word from the command decoder. This verification message shall consist of 2 filler bits, 7 command bits and a parity bit.

In the LSP Formatting mode, the Central Station shall accept serial NRZ(c) formatted digital data from the LSP subsystem. The data rate shall be 3. 533 kb/s ± . 01%. Upon command the LSP data rate shall be changed to 1060 b/s. Clock signals at 3533 Hz or 1060 Hz, and at 28. 267 KHz, shall be provided to the LSP by the Central Station Data Processor.

In the LSP Mode the format shall be 20 thirty bit words in each subframe, with 3 subframes per frame. The complete LSP format shall be as defined in IC 314131 and in Figure 11.

The formatted NRZ-c data from the appropriate stage of the Central Station Data Processor (D/P Formatting Mode) or from the LSPE (LSP Formatting Mode) shall be encoded by the Central Station Data Processor into a split-phase signal with the following characteristics:

NRZ-c '0' represented by split-phase "01"

NRZ-c '1' represented by split-phase '10'

The split-phase signal shall phase modulate the transmitter as follows:

Split-phase '0' causes negative phase transition

Split-phase '1' causes positive phase transition

The transmitter output power shall be 1.0 watt minimum at 2275.5 MHz into a 50-ohm load with a maximum VSWR of 1.5:1. The effective radiated power (ERP) from the antenna shall be greater than +42.5 dbm when using a peak antenna gain of 15.2 db. The split-phase data shall phase-modulate the carrier with a modulation index of 2.5 radians ± 5 percent. The frequency accuracy and stability shall be better than ±0.0025 percent per year under all operating conditions.

3.1.1.3 Modes of Operation

The Central Station data subsystem shall be capable of operating in four separate modes as follows:

Data Processor Formatting - Normal Bit Rate

Data Processor Formatting - Slow Bit Rate

LSP Formatting - Normal Bit Rate

LSP Formatting - Slow Bit Rate

The operation of the ALSEP system in each of these modes is summarized in Table L

TABLE I

DATA SUBSYSTEM MODES OF OPERATION

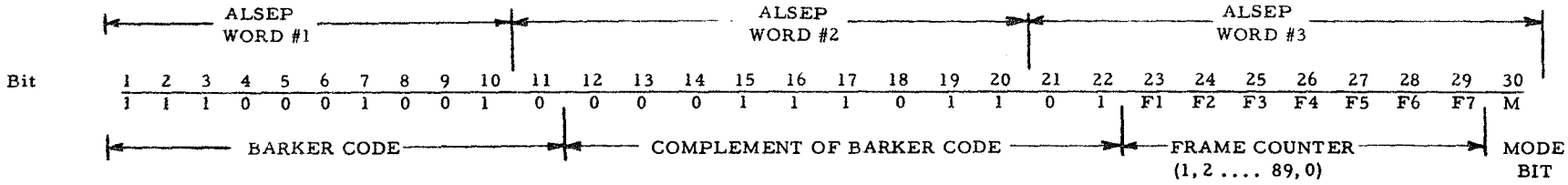
Mode	Frame Time	Experimental Data	Analog Information
D/P Normal	604 Millisec	From all experiments of complement except LSPE; data rate: 1060 bps	Normal format-up to 90 Housekeeping Channels plus Reserve Power
D/P Slow	1.208 sec.	From all experiments of complement except LSPE; data rate: 530 bps	Normal format -up to 90 Housekeeping Channels plus Reserve Power
LSPE Normal	509.4 millisec	LSP only; data rate 3.533 kilobits/sec	12 Housekeeping channels
LSPE Slow	1.698 sec	LSP only; data rate 1.060 kilobits/sec	(5 from LSPE; 7 from the rest of ALSEP, including Reserve Power).

3.1.1.4 Control Word

The telemetry format in the Data Processor Formatting mode shall contain 30 bits per frame for synchronization and identification purposes. The synchronization word shall consist of an 11-bit Barker Code followed by its complement. The remaining 8 bits shall be used for frame, mode, and station identification as shown in Figure 7.

The telemetry format in the LSP Formatting Mode shall contain 10 bits in each sub-frame for synchronization purposes, as shown in Figure 11.

CONTROL WORD FORMAT



Symbol	Name	ALSEP Words	Range	Bits/ Sample	Samples/ Second (at normal data rate)
DA-1	Barker Code and Complement	1, 2, and bits 1 and 2 of word 3	NA	22	1.66
DA-2	Frame Count	Bits 3 to 9 inclusive of word 3	0-89	7	1.66
DA-3	Bit Rate ID	Bit 10 of word 3		1	1/54
		Frame: 1 — Mode Bit: 1 — Meaning: Normal data rate			
		Frame: 2 — Mode Bit: 1 — Meaning: Slow data rate			
DA-4	ALSEP ID	Bit 10 of word 3		3	1/54
		Frame: 3 — Mode Bit: X(MSB) — Meaning: Data processor ID Number			
		Frame: 4 — Mode Bit: X — Meaning: Data processor ID Number			
		Frame: 5 — Mode Bit: X — Meaning: Data processor ID Number			

FIGURE 7. CONTROL WORD FORMAT

3. 1. 1. 5 Power Distribution

The Central Station Subsystem shall accept power from the electrical power subsystem at a nominal 16 volt DC (see Specification IC 314119) and shall provide power to the experiments at a nominal +29 volts DC. The +29 VDC to each experiment shall be switched 'ON', 'STANDBY' and 'OFF' by Earth command, the required relays and associated circuits being located in a pair of redundant Power Distribution Units (PDU).

The actual voltage at each Central Station/experiment interface will be a function of the regulation of the PCU and the voltage drop through the series resistance of the PDU and the harness. For a current range of 100 mA to 500 mA in an experiment supply line the voltage at the interface shall not be worse than 29. 2 ± 0. 4 volts less the drop in a series resistance not exceeding 2. 5 ohms i. e. , the voltage at the interface shall at no time be outside the limits +29 VDC + 2% -5%.

All switching operations shall be accomplished within a period of 10 μ sec.

3. 1. 1. 5. 1 Power Circuit Protection

Power circuit protection shall be provided to ensure operation of the ALSEP Central Station Subsystem and all remaining experiment subsystems if a failure occurs within any experiment subsystem. The protection level for each experiment operational power line shall be 560 mA ± 10% nominal, and the experiment operate power shall be switched off if the current exceeds this level for 200 μ sec or longer. When an experiment subsystem's functional power is interrupted by the protection circuitry, standby power shall be made available to the subsystem and automatically applied on a separate line. The standby power level shall be the minimum necessary to ensure survival of the experiment. Protection of the standby powerline shall be by fuse. The design shall also provide protection for the power subsystem by automatic reduction in load in the event an overload condition exists.

3. 1. 1. 5. 2 Signal Conditioning

The C/S Data Processor unit shall provide conditioning for six RTG temperature telemetry signals (three hot frame, three cold frame), one LMS temperature telemetry signal, one LEAM temperature telemetry signal and one LSPE temperature telemetry signal. The outputs from the sensors shall be available continuously, irrespective of experiment power status.

3. 1. 1. 6 Redundancy

Redundancy shall be employed within the Central Station Subsystem to ensure subsystem operation for the required 2 years.

The techniques employed shall range from duplication of a complete component (as in the case of the transmitter) to providing redundant critical paths within a component.

3. 1. 1. 7 Astronaut Switches

The Central Station Subsystem shall provide up to 3 externally accessible switches which will allow the astronaut to control certain ALSEP functions. These switch functions shall provide the capability to:

a. Select the redundant PC #2 of the Central Station Subsystem, should PC #1 fail to start on initial turn-on.

b. Provide LSPE safety, by breaking the power supply to the LSP experiment.

c. Break the power lines to the experiment power supply relay circuits to prevent spurious power command executions executions on initial turn-on. (Final requirement for this switch will be determined after system DVM tests).

3. 1. 2 Operability

3. 1. 2. 1 Reliability

The Central Station Subsystem shall have as a design goal, a reliability of 0. 935 for mission phases including launch, flight, lunar

landing, and lunar surface operation with no single-point failure for a period of two years for the environments detailed in Specification SS100000.

3. 1. 2. 2 Maintainability

Equipment arrangements, accessibility, and interchangeability features shall be incorporated into the design to allow efficient preflight servicing and maintenance. Equipment checkout, field maintenance, and replacement of the Central Station Subsystem shall be at the component level. DS-1, DS-7, PS-37 and MIL-STD-721 shall apply.

3. 1. 2. 3 Useful life

The Central Station Subsystem shall be capable of performing as specified herein during all phases of lunar day and lunar night for a period of two years following a maximum Earth storage period of 3 years.

3. 1. 2. 4 Natural Environment

The Central Station Subsystem shall be capable of performing as specified herein during or after being subjected to the applicable environmental conditions specified in Specification SS100000.

3. 1. 2. 5 Transportability

Transportability requirements for the Central Station Subsystem shall be as specified in Specification SS100000.

3. 1. 2. 6 Human Performance

Human performance requirements for the Central Station Subsystem shall be as specified in Specification SS100000.

3. 1. 2. 7 Safety

Safety requirements for the Central Station Subsystem shall be as specified in Specification SS100000.

3.1.2.8 Induced Environment

The induced environment requirements shall be as shown in Specification SS100000.

3.1.2.9 Electric & Magnetic Field Cleanliness

The Central Station Subsystem shall not produce significant contaminant electric or magnetic field at susceptible experiments. The electric field induced by the C/S subsystem shall be less than 25 volts per meter at 10 feet at frequencies less than 10 Hz. The magnetic field contamination shall be less than 10 gammas as 10 feet at frequencies less than 30 Hz. The residual Central Station Subsystem magnetic field shall be less than 10 gammas at 10 feet after exposure to a magnetic field of 25 gauss.

3.1.2.10 Failure Protection

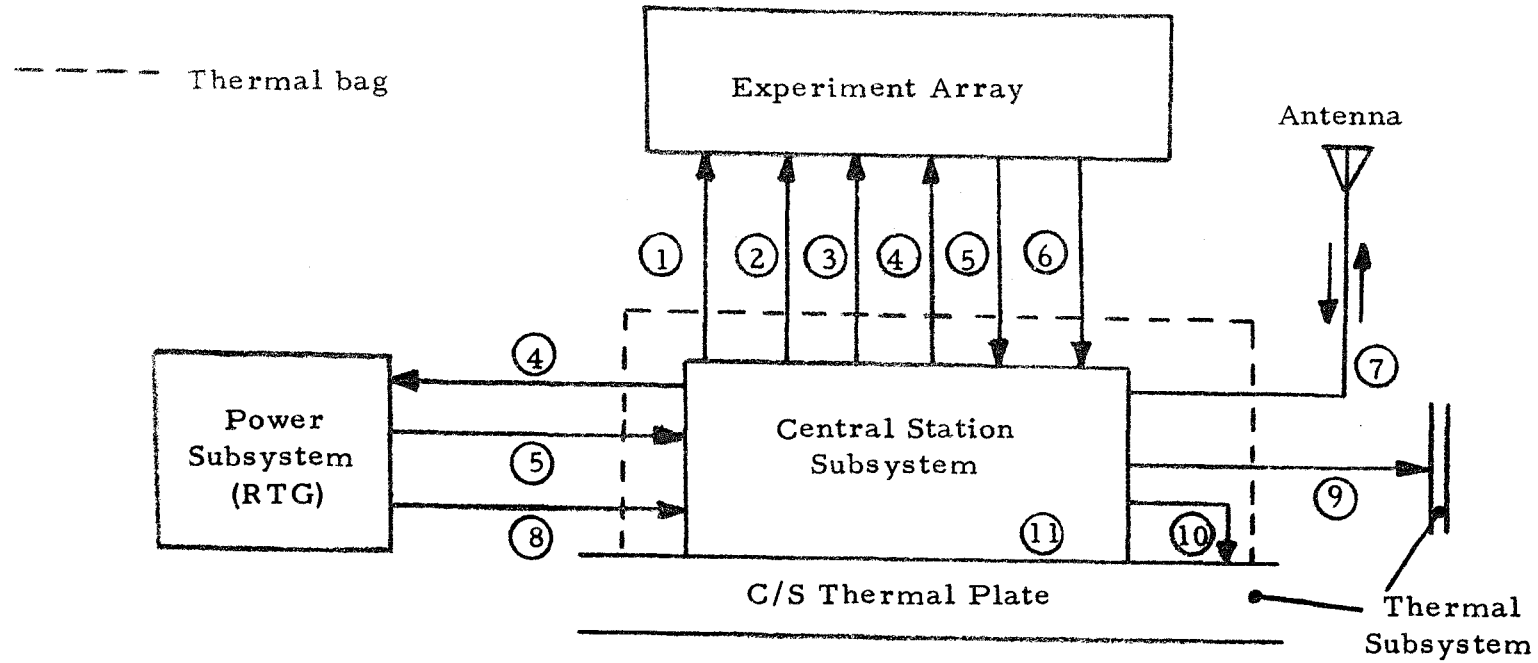
Part or component failures shall not propagate sequentially. All outputs and inputs to the Central Station Subsystem shall be designed such that short circuiting or open circuiting on any line will not impair performance on any other line.

3.2 Interface Requirements

The Central Station Subsystem shall be capable of interfacing with the ALSEP equipment as shown in Figure 8.

3.2.1 Mechanical Interface

The Central Station Subsystem shall mechanically interface only with the thermal plate, except for the antenna. The arrangement of the components on the thermal plate is shown in Figure 9. A volume of approximately 730 cubic inches shall be provided for housing of all portions of the data subsystem with the exception of the helical antenna aiming mechanism, and antenna-diplexer interconnecting cable. Environmental temperature requirements are shown in Specification SS100000.



Legend:

1. Control and timing signals
2. Commands
3. Command switched power lines
4. Conditioned power for RTG, LMS, LEAM and LSPE temperature telemetry sensors.
5. Analog housekeeping data (engineering and status)
6. Digital data
7. RF input and output
8. Prime power
9. External power dumping
10. Internal power dumping
11. The C/S subsystem units excluding the antenna are thermally and mechanically secured to the thermal plate.

Figure 8 - ALSEP Central Station Subsystem Interfaces

COMPONENTS/THERMAL PLATE LAYOUT

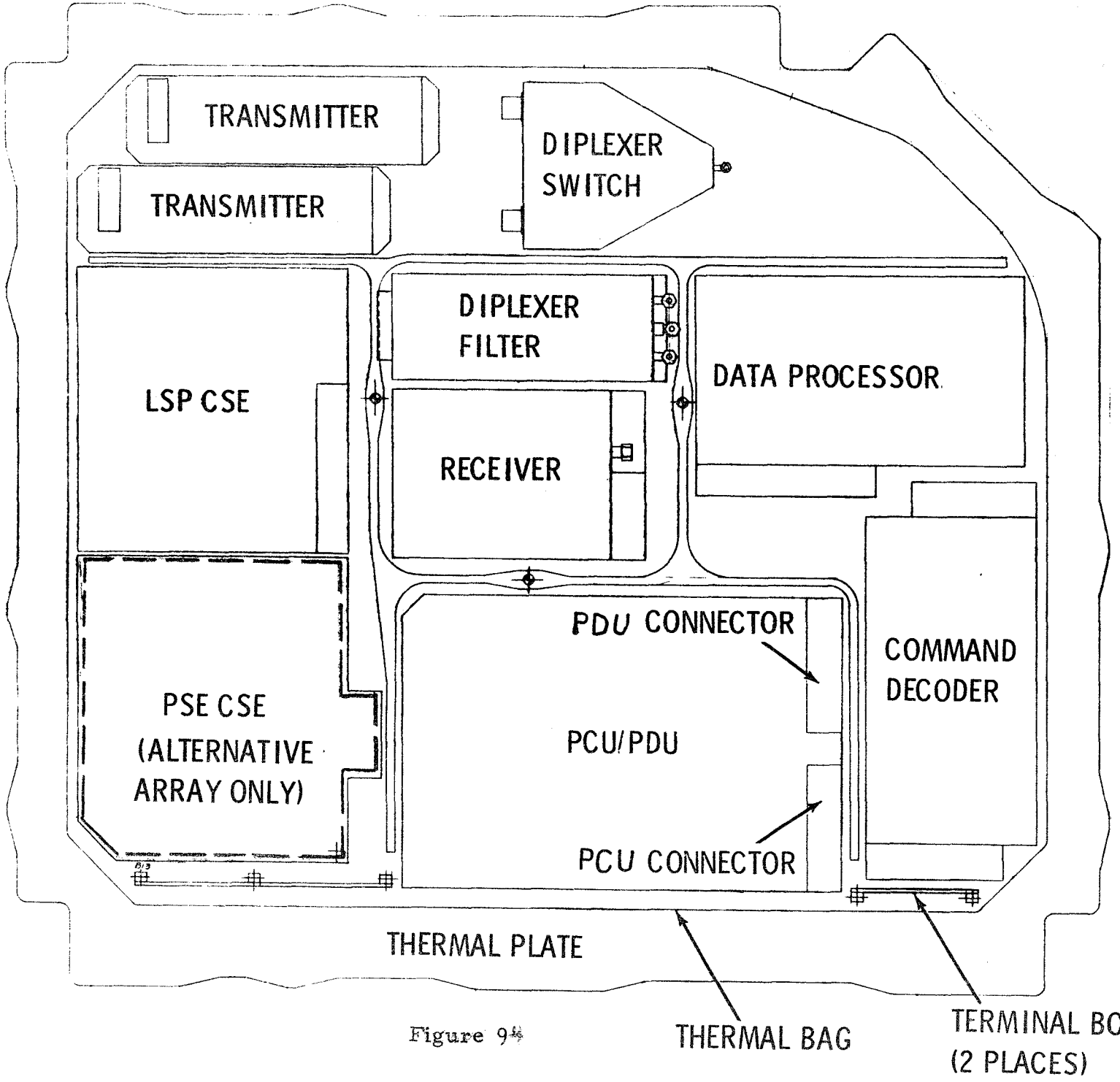


Figure 9

3. 2. 1. 1 Antenna Assembly Interfaces

The antenna assembly shall consist of a right-hand circularly polarized Helical Endfire Antenna, an antenna aiming mechanism, and a coaxial cable. The antenna design shall allow proper pointing by the astronaut from a standing position. The antenna shall provide optimum Earth coverage for two years after pointing.

The antenna assembly interfaces are described as follows:

The antenna shall be affixed by its ground plane to the aiming mechanism by a quick-connect method for rapid assembly by the astronaut. The aiming mechanism will be affixed to the antenna mast by a similar quick connect method as is used above. Key ways on the aiming mechanism shall orient the antenna with reference to the Central Station. The coaxial cable shall be connected to the antenna and diplexer prior to stowage so the astronaut will not be required to make RF connections.

3. 2. 2 Electrical Interface

The electrical interface with the Central Station Subsystem is broken down into specific interfaces with other subsystems of ALSEP. These are listed in the following sub-paragraphs.

3. 2. 2. 1 Experiment Interface

The experiment data subsystem electrical interface shall be as shown in Table II. Interfaces with all experiments are detailed although a specific ALSEP will not contain all the experiments.

Characteristics of the signals listed in Table II are defined in the following paragraphs.

3. 2. 2. 1. 1 Digital Data

Digital data are taken from the experiments in 10-bit words at the times specified by telemetry format, Figure 10. The LSP formats its own data, Figure 11. Control and timing signals in the form of a demand pulse (paragraph 3. 2. 2. 1. 3 (d) and shift pulses (paragraph 3. 2. 2. 1. 3 (a))

TABLE II

EXPERIMENT/CENTRAL STATION SUBSYSTEM INTERFACES

Experiment	Digital Data	Engineering and Status Lines	Control/Timing Signals	Power	Commands Allocated Via Command Link
Passive Seismic specification IC 314106	45 ten-bit words per frame	8 analog status data lines	Even frame mark Data Gate Shift Pulse Data Demand Data Gate	See IC 314106	16 separate command lines
Lunar Mass Spectrometer Specification IC 314132	4 ten-bit words per frame	3 analog status data lines	90th frame mark Frame Mark Data Demand Shift Pulse	See IC 314132	7 separate command lines
Lunar Surface Gravimeter Specification IC 314133	36 ten-bit words per frame	10 analog status data lines	90th Frame Mark Frame Mark Shift Pulse Data Demand Data Gate Pulse	See IC 314133	7 separate command lines
Heat Flow Specification IC 314109	1 ten-bit words per frame	6 analog status data lines	90th Frame Mark Frame Mark Shift Pulse Data Demand	See IC 314109	10 separate command lines
Lunar Seismic Profiling Experiment Specification IC 314131	LSPE takes over complete formatting. Sixty 30-bit words/frame	7 analog status data lines to LSPE from C/S Subsystem. One analog to C/S Subsystem from LSPE	Shift Pulse High frequency clock (28.267 kHz).	See IC 314131	5 separate command lines
Lunar Ejecta and Meteorites Specification IC 314130	2 ten-bit words per frame	3 analog status data lines	90th Frame Mark Frame Mark Data Demand Shift Pulse	See IC 314130	4 separate command lines

Array E

Experiment Group 1

Symbol	Experiment	
J	LEAM	(2 Words)
HF	HFE	(1)
A	LMS	(4)
G	LSG	(36)

Experiment Group 2

Symbol	Experiment	
J	LEAM	(2 Words)
HF	HFE	(1)
A	LMS	(4)
X/-/o	PSE	(45)

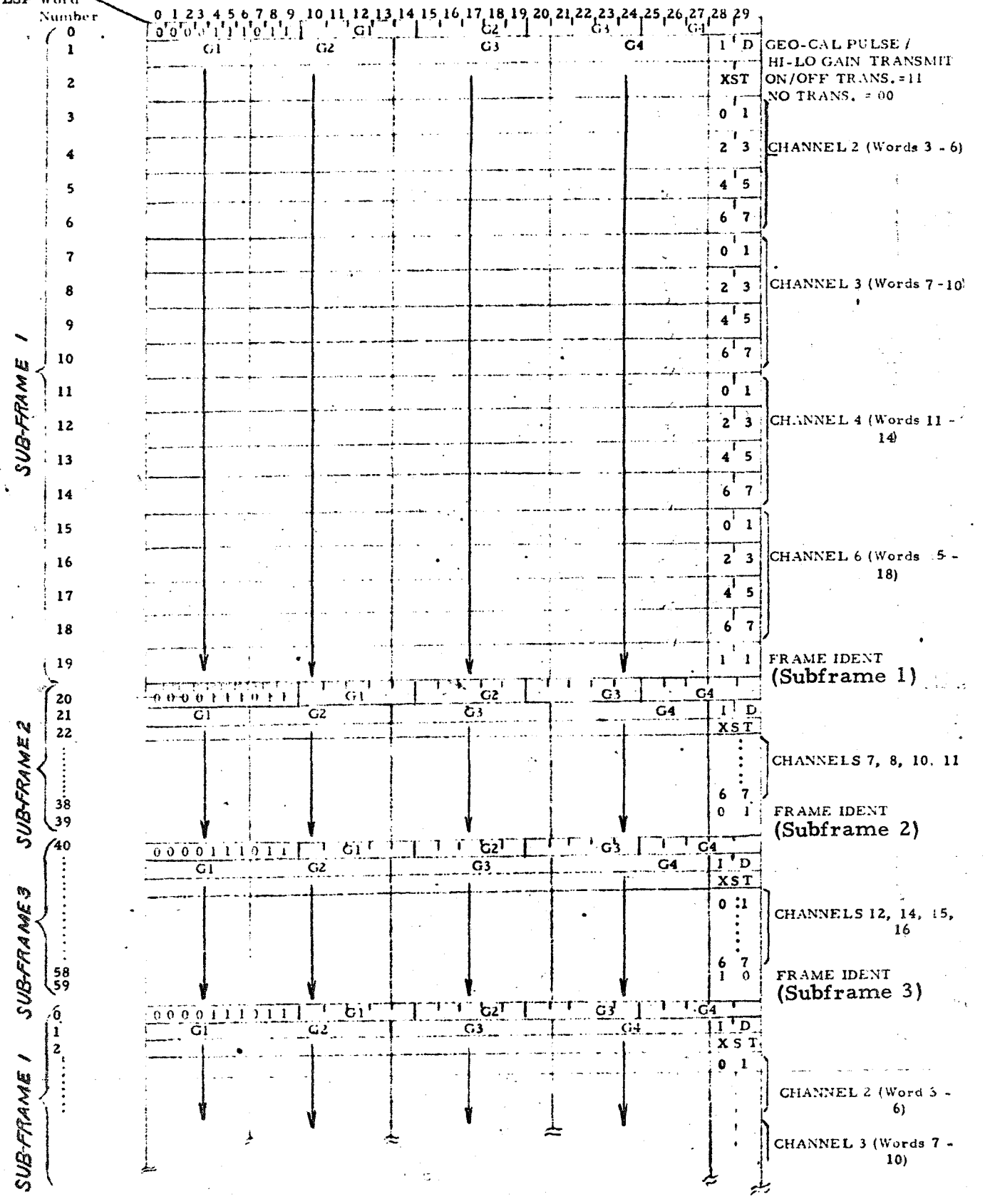
Each box contains one ten bit word. Total bits per frame = 10 x 64 = 640 bits

x	x	x	G	A	G	CV	8 G
	G		G		G		16 G
A	G	A	G	A	G	HF	24 G
G	G	G	G	G	G	J	32 G
HK	G	G	G	G	G	J	40 G
	G		G		G		48 G
	G		G		G		56 G
	G		G		G	R	64 G

x	x	x	X	A	X	CV	X
-	X	-	X	-	X		X
A	X	A	X	A	X	HF	X
-	X	-	X	-	X	J	X
HK	X	•	X	•	X	J	X
-	X	-	X	-	X		X
	X		X		X		X
-	X	-	X	-	X	R	X

Blank (6)

Figure 10 Word Assignments for Array E for the Two Experiment Groups



Notes:

GEOPHONE CHANNELS

G1 - Chan. 1
G2 - Chan. 5
G3 - Chan. 9
G4 - Chan. 13

FIRST 10 BITS OF WORDS 0, 20 & 40 ARE SYNC PATTERN.

Total Bits/Frame = 1800

Figure 11 LSPE Data Format

shall be supplied by the Central Station Subsystem to synchronize the data to the Central Station Subsystem timing. Signal characterisitcs of the digital data line are as follows:

a. Logical "1" - +2.4 to +5.5 volts

b. Logical "0" - 0.0 to +0.4 volts.

Rise and fall times for all digital interface signals shall be within the limits 2 to 10 microseconds between the 10% and 90% points, except for the 28.267 kHz clock to LSPE which shall have rise and fall times not exceeding 0.2 μ sec.

The digital data interface with each experiment will be as in the circuit shown in Figure 12.

3.2.2.1.2 Housekeeping Information

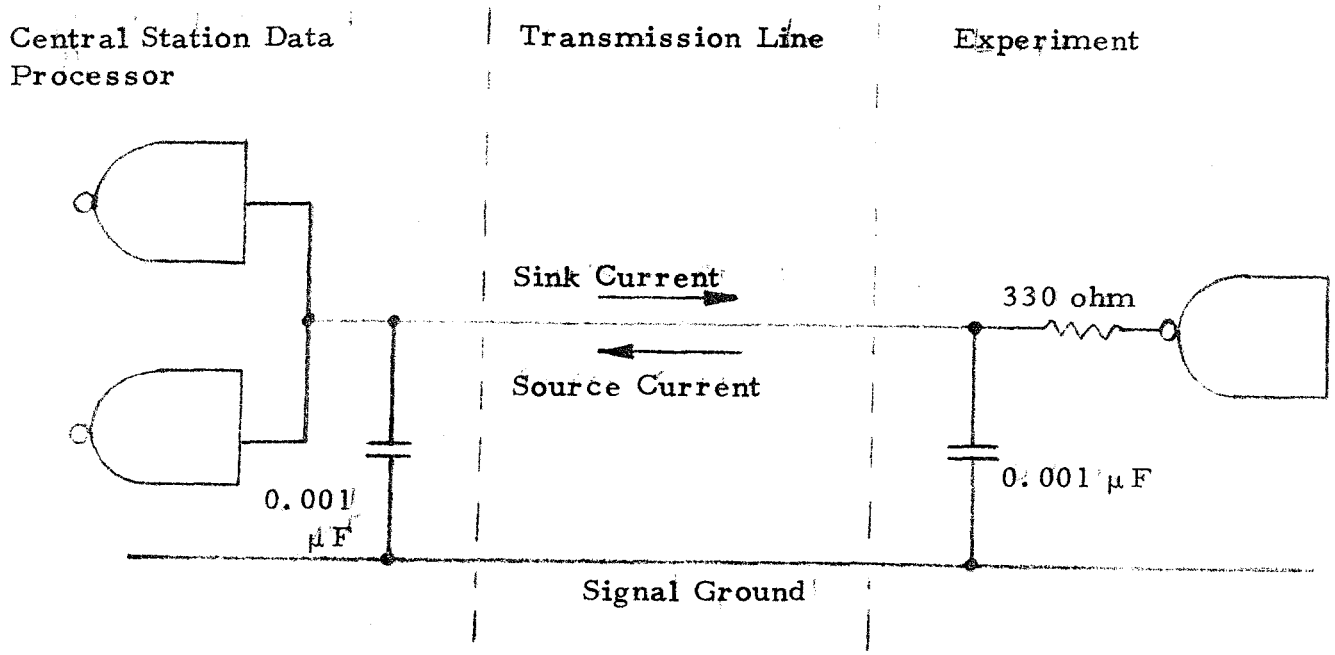
The Central Station Subsystem shall be capable of downlinking 90 multiplexed analog information signals in the range of 0.0 to +5.0 volts and shall provide 8-bit analog-to-digital conversion of these signals. The resulting 8-bit word, most significant bit first, shall be transmitted as word 33 of the telemetry frame. Two "0" filler bits shall precede the 8 information bits in the telemetry word.

The source impedance for the analog signals shall not exceed 50 k ohms. The analog status lines shall operate into the following impedances:

a. Non-sampled period 5×10^7 ohms

b. Sampled periods 10^7 ohms

The sampling period is approximately 135 microseconds. Each line shall be sampled at least once per 54 seconds during the normal mode and once per 108 seconds during the slow mode. (Exceptions to this occur when operating in the LSP mode.) The reserve power analog will be sampled once per frame via a channel independant of the multiplexer, but using the same A/D converter. Details of the analog telemetry are given in SE 33, Measurements Requirements Document.



Notes:

- Logic elements in central station Data Processor are Texas Instrument TTL 54L series.
- Only one of the dual data processor circuits is powered at any one time.
- Rise and fall times between the 10% and 90% amplitude points will be greater than 2 μsec and less than 10 μsec.
- Logical "0": 0.0 V to 0.4 V with maximum sink current of 215 μA.
- Logical "1": +2.4 V to 5.5 V with a maximum source current of 100 μA @ 2.4 V.
- Output logic element is TI TTL 54L series or equivalent.
- Fanout shall be restricted as shown in this figure.

Figure 12 Experiment/ALSEP Digital Data Line Interface Circuit

3.2.2.1.3 Control and Timing Lines

The control and timing lines shall be supplied to the experiments for control and data synchronization. The various signals generated within the Data Processor and made available as required to each experiment are shown in Figure 13. Each of the signals, as discussed below, shall be supplied on a separate line for each experiment, where required. Figure 14 shows the timing and control line interface.

The pulse rise and fall times shall be within the limits 2 and 10 microseconds between the 10% and 90% points, except in the case of the 28.267 kHz clock to LSPE, when the rise and fall times shall not exceed 0.2 μsec.

a. Shift pulse line - the shift pulse to each experiment, except LSPE, shall be a square wave signal of 1060 bps in the Normal mode and 530 bps in the Slow mode. In the case of LSPE the bit rates are 3533 bps in Normal and 1060 bps in Slow. The logical characteristics of the signal are listed below:

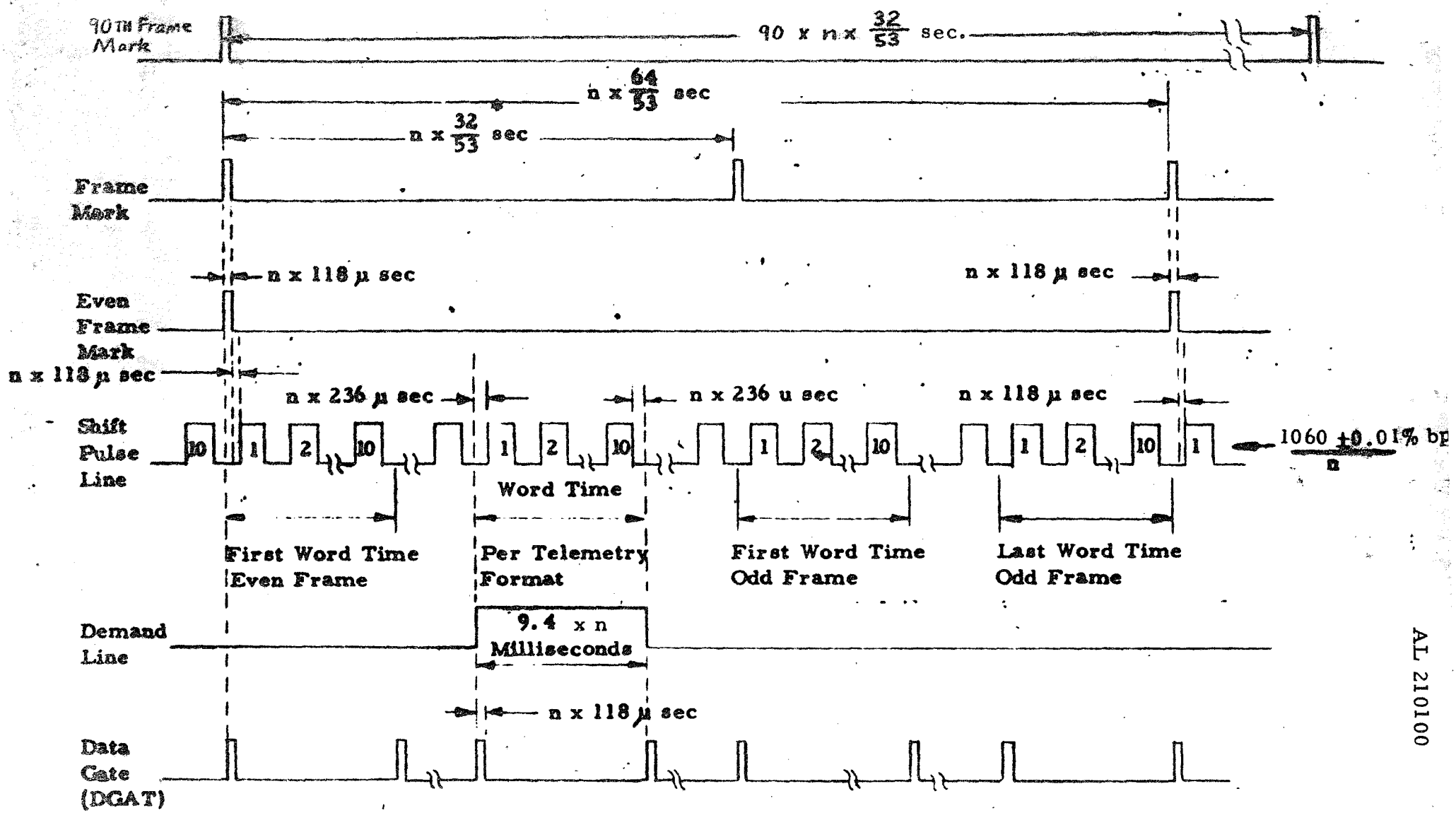
   1. Logical "1" = + 2.4 to +5.5 volts

   2. Logical "0" = 0.0 to +0.4 volts.

   The Central Station Subsystem shall sample the experiment's output at the positive going edge of the shift pulse. The experiment logic level shall be in the appropriate state within a time period of 25 microseconds before and 125 microseconds after the positive going edge of the shift pulse, where the time reference is the 50 percent point on the pulse.

b. Frame mark - a frame mark signal shall be made available to each experiment, except LSP and PSE. This shall be a pulse to signify the beginning of the telemetry frame. The characteristics of this signal shall be as tabulated below:

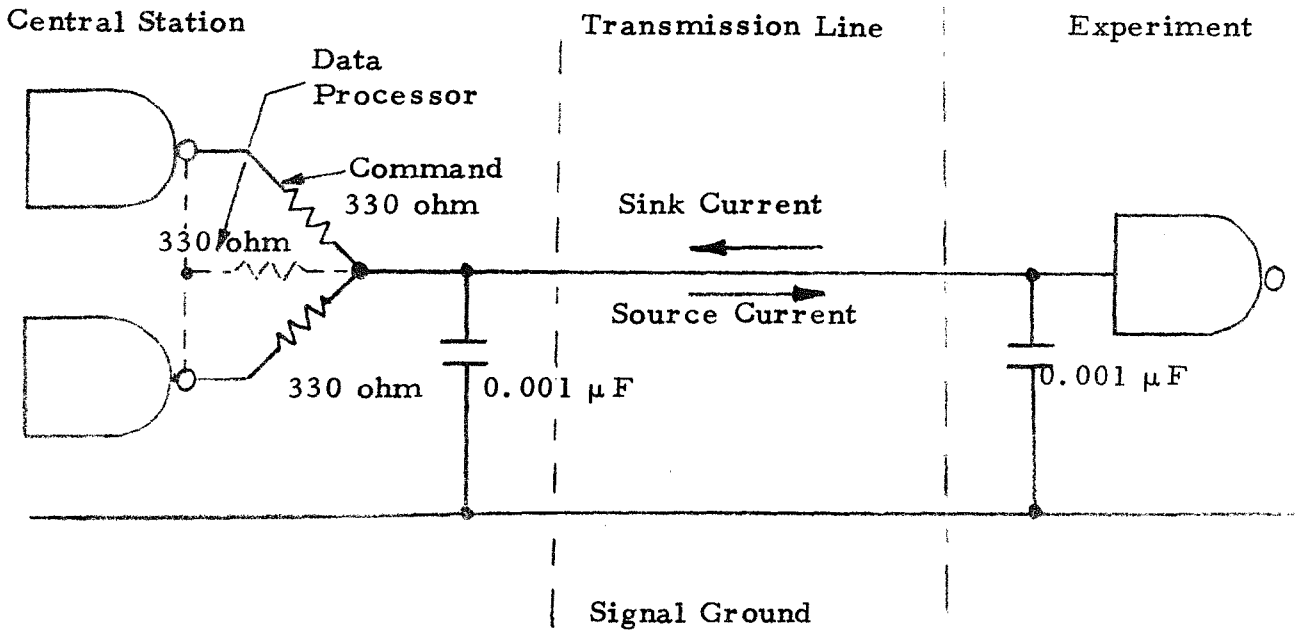
Figure 13 ALSEP Data Processor Timing and Control Signals



n = 1 for normal mode of 1060 bps
n = 2 for slow mode of 530 bps

Data Processor Reads Data at Positive Going Edge of Shift Pulse

* $\frac{32}{53}$ sec = $\frac{640 \text{ bits per frame}}{1060 \text{ bps}}$, all other times are accurate only to the significant figure shown.



Notes:

- Logical elements in Central Station are Texas Instrument TTL 54L series.
- Only one of the dual output Central Station elements is powered at any one time.
- Logical "0": 0.0 V to +0.4V with maximum sink current of 215μA.
- Logical "1": +2.4 V to +5.5 V with maximum source current of 100 μA at 2.4 V.
- Rise and fall times between the 10% and 90% amplitude points will be greater than 2 μsec and less than 10 μsec.
- Experiment logic element is TI TTL 54L or equivalent.
- Fanout shall be restricted to that shown in this figure.

Figure 14 Experiment/ALSEP Timing and Control and Command Interface Circuit

	Mode		
Characteristics	Normal	Slow	LSPE, Normal and Slow
Pulse Width Pulse Rate	118 μsec 53/32 per sec	236 μsec 53/64 per sec	118 μsec 53/32 per sec

1. Logical "1" = + 2.4 to + 5.5 volts

2. Logical "0" = 0.0 to + 0.4 volts.

c. Even frame mark - an even frame mark signal shall be made available to the Passive Seismic Experiment. This shall be a pulse to signify the beginning of each even numbered telemetry frame. The characteristics of this signal shall be as tabulated below:

	Mode	
Characteristics	Normal	Slow
Pulse Width Pulse Rate	118 μ sec 53/64 per sec	236 μ sec 53/128 per sec

1. Logical "1: = + 2.4 to + 5.5 volts

2. Logical "0" = 0.0 to + 0.4 volts.

d. Data demand - this signal shall be provided to the experiments to signify the time at which digital data shall be accepted from the experiments. This signal shall remain in the active state (Logical "1") for 10 shift pulse times each time a telemetry word is required from the given experiment (See Figure 13). The characteristics are listed below:

1. Logical "1" = + 2.4 to + 5.5 volts

2. Logical "0" = 0.0 to + 0.4 volts.

e. Data gate - this pulse shall be provided only to the Lunar Surface Gravimeter Experiment or the Passive Seismic Experiment. Its level and width shall be identical with those of the frame marks. Its rate shall be 1/10 the shift pulse rate (equal to the telemetry word rate) and its leading edge shall be coincident with that of the data demand pulse. (See Figure 13.)

f. High Frequency Clock - this is a 28.267 kHz square wave supplied only to the Lunar Seismic Profiling Experiment. The interface shall be as in Figure 14, but the 330 ohm and the two 0.001 μF rise-time components shall be omitted.

3.2.2.1.4 Commands

Each experiment shall be supplied with the number of ground commands indicated in Table II, each command being supplied to the experiments on a separate wire. The command signal shall be a negative-going pulse with the characteristics listed below:

a. Logical "1" = + 2.4 to + 5.5 volts (normal inactive state)

b. Logical "0" = 0.0 to + 0.4 volts (active state)

c. Pulse width = 20 ± 2.0 milliseconds.

The command line interface shall be as in Figure 14.

In addition to the ground commands, automatic periodic command pulses shall be generated by the Command Decoder in the Central Station Subsystem as follows, starting at power turn-on:

a. At intervals of 15.4 hours, one pulse on Cmd Octal 065, PSE "SP Cal", and two pulses four minutes apart on Cmd Octal 111 "LEAM CALIBRATE".

b. At 7 hours and then at intervals of 61 hours an Uplink Switch command, Octal 122.

These automatic command pulses are 18.8 milliseconds in length in Normal bit rate and 37.6 milliseconds in Slow bit rate. The pulses in Para (a) can be permanently inhibited by ground command (Octal 105) until re-enabled by ground command Octal 104.

Each pulse in (b) can be individually inhibited by ground command (Octal 174) but it will not be possible to permanently inhibit all pulses. A complete listing of Array E commands is given in ATM 930.

3.2.2.1.5 Power Lines

Power lines shall be supplied to each experiment. The source of the power is the Power Conditioning Unit (PCU). Experiment power is routed through, and controlled by the Power Distributing Unit (PDU) of the Central Station Subsystem. Experiment power shall be supplied as follows:

a.	Operate power	+29 volts-circuit breaker protection (560 mA ± 10%)
b.	Standby power	+29 volts-fuse protection (Nominally 500 mA)
c.	Ground return(s).	

In addition, the Central Station Subsystem shall provide +12 volt conditioned outputs for temperature sensors in the LEAM, LMS, and LSP experiments, and constant current drives to six temperature sensors in the RTG (three hot frame, three cold frame).

The actual voltage level of the nominal +29 volt supplies to the experiments shall be as defined in Paragraph 3.1.1.5.

3.2.2.1.6 Noise

Noise and electrical transients induced on the data, timing and control, and command lines by the Central Station Subsystem shall not exceed 100 millivolts peak-to-peak, measured at the Central Station Subsystem interface points. The noise on the +29 volt power lines shall not exceed 150 millivolts peak-to-peak including the effect of load cross talk through the common power impedance.

3.2.2.1.7 Common System Ground

The thermal plate of the Central Station shall be the effective single point ground for the whole ALSEP system. All points on the thermal plate shall be electrically equivalent.

3.2.2.2 Power Interfaces

3.2.2.2.1 Power Requirements

Exclusive of the power required for distribution to experiments, central station heaters and the power dissipation module, the Central Station Subsystem shall require no more than 25 watts of electrical power to perform all functions. This power shall be supplied at nominal direct current potentials of +29, +12, +5, and -12 volts. The primary power supply from the RTG shall be in the range 68 to 80 watts, at +15.6 to +16.6 volts.

Should the power source be overloaded, the potentials received by the Central Station Subsystem may simultaneously drop by as much as 20% for up to 120 milliseconds. It is required that functions of the subsystem not be permanently impaired by this drop in supply voltage levels.

3.2.2.2.2 Power Distribution

All electrical power for functional operation of the Central Station Subsystem and for distribution to experiments and other loads, shall be provided as detailed in component specification AL 310210.

3.2.2.2.3 Electrical Load Characteristics

During data collection, processing and transmission, the data subsystem shall not generate any periodic or transient voltages on the +5 volt, +12 volt, and -12 volt power lines in excess of 100 millivolts peak to peak.

3.2.2.2.4 Optimized Reserve Power Distribution

To optimize thermal control, the Central Station Subsystem shall provide on/off switching, controlled by ground command, for two resistive loads connected to the +29 volt line. These loads shall be in the Power Dissipation Module which is located external to the thermally controlled area of the Central Station, and shall be for dissipations of 7 watts and 14 watts.

Maintenance of adequate reserve power for regulation shall be provided by the Command Decoder, by automatic switching of dumps to 'OFF' and experiments from an operational to standby mode. This "Ripple-OFF" sequence shall be initiated 120 milliseconds (maximum) following depletion of the power reserve in the power subsystem and shall be stopped when the power reserve is restored. The fixed dumps and experiments shall be sequentially switched to a standby mode at intervals of 8 ± 1 milliseconds.

3.2.3 Thermal Subsystem Interface

The Central Station Subsystem, except the Power Dump Module, antenna and interconnecting RF cable, shall be contained within the thermally controlled area of the Central Station. The components shall be mounted to a thermal plate to provide temperature control. The thermal plate average operating temperature shall be maintained within the range of 0° to +135°F, in any normal ALSEP system operating mode, with a minimum of 74 watts and a maximum of 80 watts RTG power into the PCU. To achieve this temperature, it shall be assumed that the Central Station is leveled and aligned in accordance with AL 240000 and that the APM and PDR dumps may be used as required.

3.3 Design and Construction

The Central Station Subsystem shall be designed and constructed in such a manner that it complies with all requirements detailed in this specification.

3.3.1 General Design Features

3.3.1.1 Size

The components of the Central Station Subsystem shall be configured as shown in the relevant interface control specifications.

3.3.1.2 Weight

The weight of the C/S subsystem including the Central Station harness and thermal container shall not exceed 37.0 pounds and shall have a target weight of 33.0 pounds.

3.3.1.3 Center of Gravity

The center of gravity of the components of the Central Station shall be kept as close to their mounting base plates as practical.

3.3.2 Selection of Specifications and Standards

Requirements for selection of specifications and standards shall be in accordance with Specification SS100000.

3.3.3 Materials, Parts, and Processes

Materials shall be selected from the approved materials list ATM-242E Parts shall be selected from the Acceptable Parts List ATM 241E. All parts, materials, and processes shall be compatible with the intended use and shall be compatible with the environmental requirements specified in paragraph 3.1.2.4 herein.

In general the following types of materials shall not be used without prior written approval of the Bendix Parts and Materials Group.

a. Flammable materials

b. Toxic materials

c. Unstable materials

d. Plastic (only epoxy-resin-based compounds, Teflon, Mylar and Kapton shall be used)

e. Dissimilar metals in direct contact which tend toward active electrolytic or galvanic corrosion.

3.3.4 Moisture and Fungus Resistance

Materials which are not nutrients for fungus shall be used whenever possible. The use of materials which are nutrients for fungus shall not be prohibited in hermetically sealed assemblies and in other accepted and qualified uses such as paper capacitors and treated transformers. If it is necessary to use fungus-nutrient materials in other than such qualified application, these materials shall be treated with a process which will render the resulting exposed surface fungus-resistant.

3.3.5 Corrosion of Metal Parts

Metals shall be corrosion-resistant type or suitably treated to resist corrosive conditions likely to be met in storage or normal service. Unless suitably protected against electrolytic corrosion, dissimilar metals, as defined in Standard MIL STD 889, shall not be used in direct physical contact.

3.3.6 Interchangeability and Replaceability

Interchangeability shall comply with the requirements of paragraph 3.1.2.2 herein. Items of equipment with the same part number shall be physically and functionally interchangeable. MIL-STD-721 shall apply.

3.3.7 Workmanship

Workmanship requirements for the data subsystem shall comply with the requirements of Specification SS100000.

3.3.8 EMI and Grounding

The Central Station shall satisfy Electromagnetic Interference Specification AL 770000 at the subsystem level.

Electronmagnetic Compatibility shall be a consideration in the design, layout, and packaging of all electronic and electrical circuitry. Standard practices and procedures contributing to reduction of EMI shall be employed.

Chassis returns, signal returns, shields and power returns will be tied to any part of the Central Station thermal plate, which shall be treated as the effective single point ground for the system.

3.3.9 Identification and Marking

The data subsystem shall be marked for identification in accordance with Standards MIL-STD-130B.

3.3.10 Storage

The data subsystem shall perform as specified herein following storage for the period specified in paragraph 3.1.2.3.

3.4 Requirements for Subareas

Requirements for subareas are specified in the specifications listed for the equipment shown in 3.1 herein.

4.0 QUALITY ASSURANCE PROVISIONS

The Bendix Aerospace Systems Division Quality Assurance Plan for ALSEP BSR 2777 shall implement the requirements of Section 3.0. This provides effective implementation of a Quality Program in full compliance with NHB 5300.4 (1B).

4.1 Formal Qualification Test

The following subparagraphs specify the requirements for the methods of formally verifying that each requirement in Section 3 of this specification has been satisfied.

4.1.1 Inspection

The following requirements of Section 3 of this specification shall be verified by an inspection of the Central Station prior to system qualification testing:

3.2.1	Schematic arrangement
3.2.2.1	Mechanical interface
3.3.1.1	Size
3.3.1.2	Weight
3.3.1.3	Form factor
3.3.3	Materials, parts, and processes; standard and commercial parts
3.3.7	Workmanship
3.3.9	Identification and marking

4.1.2 Analysis

The following requirements of Section 3 of this specification shall be verified by review of analytical data:

3.1.2.1 Reliability

3.1.2.2 Maintainability

3.1.2.3 Useful life

3.3.10 Storage

4.1.3 Demonstrations

The following requirements of Section 3 of this specification shall be verified by demonstration:

3.1.2.5 Transportability

3.1.2.6 Human performance

3.1.2.7 Safety

3.3.6 Interchangeability

4.1.4 Tests

The following requirements in Section 3 of this specification shall be verified during the formal qualification program.

4.1.4.1 Functional Tests

3.1.1 Operational characteristics

3.2.2.2 Electrical interfaces

4.1.4.2 Environmental Tests

Environmental tests will be conducted to verify that the requirements of paragraph 3.1.2.4, (natural environment) and paragraph 3.1.2.8, (induced environment) of this specification are met.

4.1.4.3 EMI Tests

Testing to assure that the data subsystem meets the requirement of paragraph 3.3.8 of this specification shall be accomplished in accordance with applicable EMI test requirements.

5.0 PREPARATION FOR DELIVERY

None required. Subsystem is delivered as part of contract end item.